DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-161605

SOLAR DOMESTIC HOT WATER SYSTEM INSTALLED AT TEXAS CITY, TEXAS - FINAL REPORT

Prepared from documents furnished by

LaQuinta Motor Inns, Inc.
Post Office Box 32064
San Antonio, TX 78216

Under DOE Contract EG-77-G-01-1670

Monitored by

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

U.S. Department of Energy

Solar Energy

TABLE OF CONTENTS

TEXAS CITY, TEXAS

I. KEY WORD ABSTRACT

Application	Domestic Hot Water
Collector Type	Flat Plate, Liquid
Collector Manufacturer	Raypak, Inc.
Collector Area	2100 sq. ft. (Approximate)
Storage Capacity	2500 gallons
Hot Water Load	5.83×10^8 BTU/year
BTU's Produced	3.67×10^8 BTU/year
Building Owner	La Quinta Motor Inns, Inc.
Solar System Designer	Travis-Braun & Associates
Contractor (Installer)	Solar-Dronics

II. INTRODUCTION

La Quinta Motor Inns, Inc. retained Travis-Braun & Associates to design a solar assisted domestic hot water system for the new 98 unit La Quinta Motor Inn in Texas City, Texas. The system was designed to supply approximately 63% of the total hot water load. The Inn is a low-rise, two story building with flat roof for installation of solar panels.

III. DESIGN PHILOSOPHY

The Texas City, Texas property was chosen for solar installation because of the favorable climatic condition and also because electric hot water heating was specified for this property in response to the Government's request to conserve natural gas during the energy crunch of the 1970's.

The system consists of eleven banks of nine collectors, each mounted on the roof of the property. Originally, the system was designed as a drain down system. But, at the recommendation of the installing contractor, the design was changed to an ethylene glycol system. Balancing valves were installed to regulate the flow to the solar panels. Throughout the system, Pete's Plugs were installed for temperature and pressure measurements.

Two heat exchanger tube bundles were installed in the 2500 gallon storage for transferring the solar heat to the domestic hot water system.

A. Collectors

The collectors chosen for this project were Model SG-18P manufactured by Raypak, Inc. A total of 99 collectors were used. The collectors were supplied with Model PR-18 Solar Panel Rack Kit. (See attached sheets on Raypak collectors.)

B. Storage System

A 2500 gallon insulated vertical steel storage tank was located outdoors next to the Inn's cooling tower. A temperature sensor was installed in the storage tank for control function. To improve heat transfer between the heat exchangers and stored water, a 1/12 HP Grundfos recirculating pump was installed.

C. Heat Exchangers

Two heat exchanger tube bundles were mounted into the storage tank. The upper heat exchanger which served to extract heat from the storage tank to the domestic hot water system was sized for 100 gpm at 10°F temperature rise. The lower heat exchanger which served to transfer heat from the solar collectors to the storage tank was sized for 51 gpm at 10°F temperature drop.

A solution of ethylene glycol was used as heat transfer fluid between the solar collectors and the lower heat exchanger. With the use of the upper heat exchanger for the domestic hot water system, a double wall separation was achieved between the domestic hot water system and the ethylene glycol.

D. Pump and Controls

Two solar loop pumps, each sized for 100% of the solar system requirements were installed. The pumps are controlled by a temperature differential controller with an alternator for equal usage of the pumps.

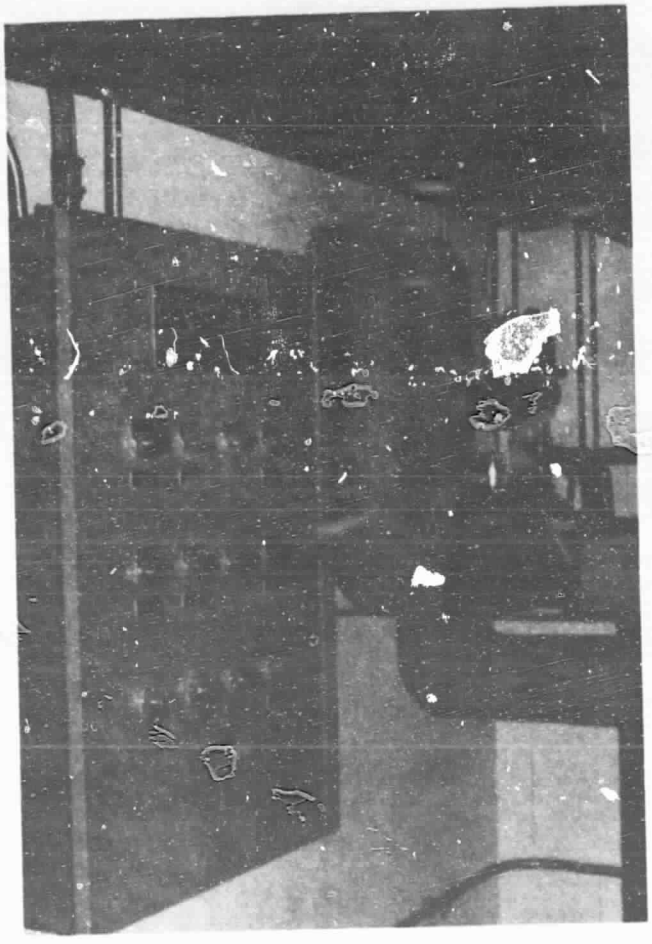
IV. OPERATION OF THE SYSTEM

The system was put into operation in the summer of 1978. Except for a few minor leaks in the piping and control adjustments, the system performed as designed and has been operating satisfactorily since then.

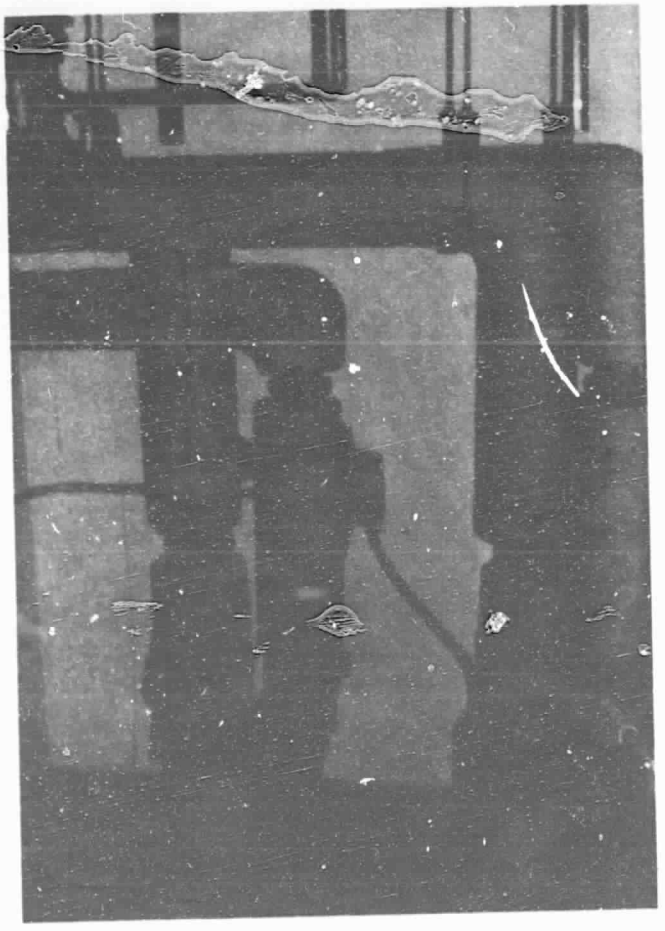
V. PROBLEMS ENCOUNTERED AND SOLUTIONS

The winter of 1978 was unusual for the area in that there was an extended period of cloudy sub-freezing temperature. To avoid any possibility of freezing the insulated 3/4" storage tank recirculating line, the control of the 1/12 HP Grundfos recirculating pump was modified so that it is also activated when the ambient temperature drops to 32°F or below.

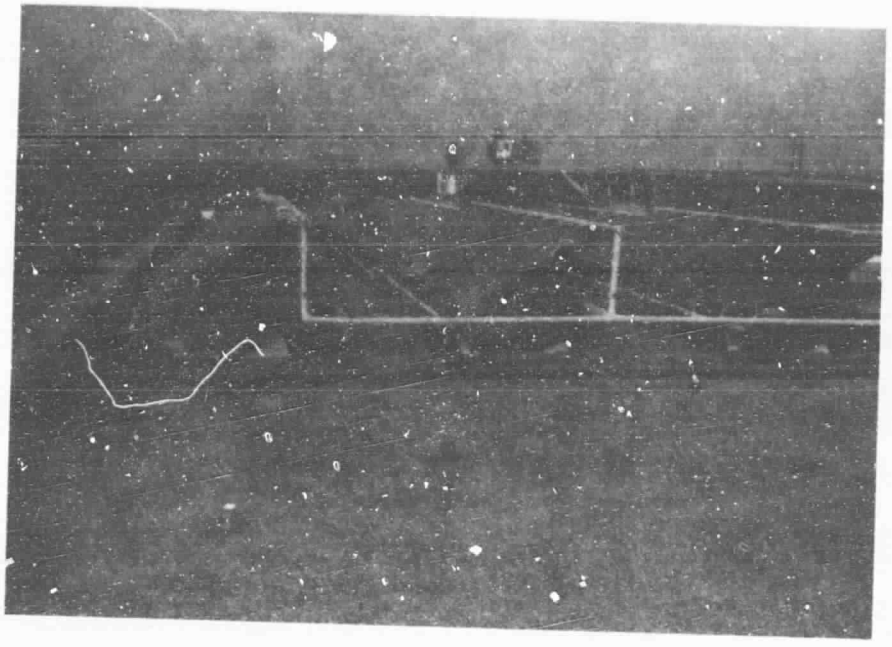
VI. PICTURES OF FINAL INSTALLATION

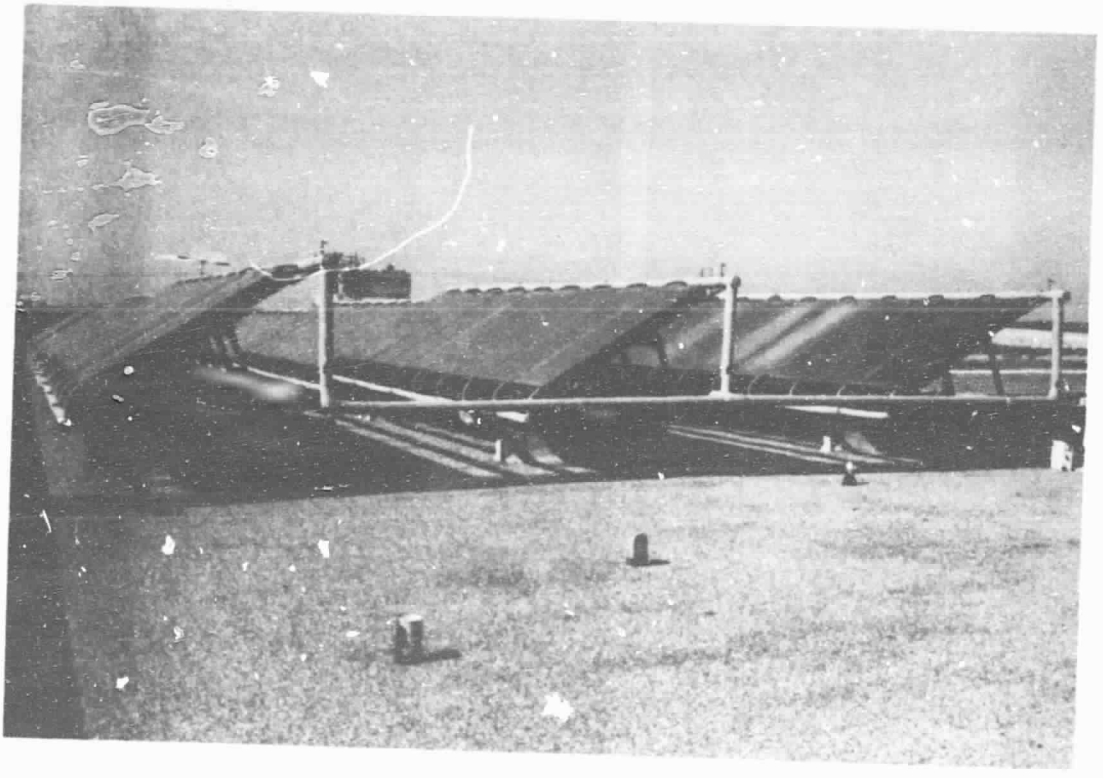


-Solar Control Panel-



-Solar Pumps-





-Solar Panels on Roof-

APPENDIX A

ROOF PLAN/SOLAR

FOR

LA QUINTA MOTOR INNS, INC.

TEXAS CITY, TEXAS

La Quinta
MOTOR INNS, INC.

October 29, 1980

National Aeronautics & Space Administration
Commercial Demonstration Office
Solar Energy Applications Projects
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Attention: Mr. Douglas W. Westrope, Jr.
Project Manager

Subject: La Quinta Motor Inns, Inc.
Texas City, Texas #533
Solar Installation

Dear Doug:

Attached is the final report on the above subject installation. Original tracings of drawings are included for your use.

Please call me if you have any questions.

Sincerely,

Ronald Wang
Mechanical/Electrical Engineer
Development Division

RW:cs

Attachments

cc: Martin Carson/file

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Development Division
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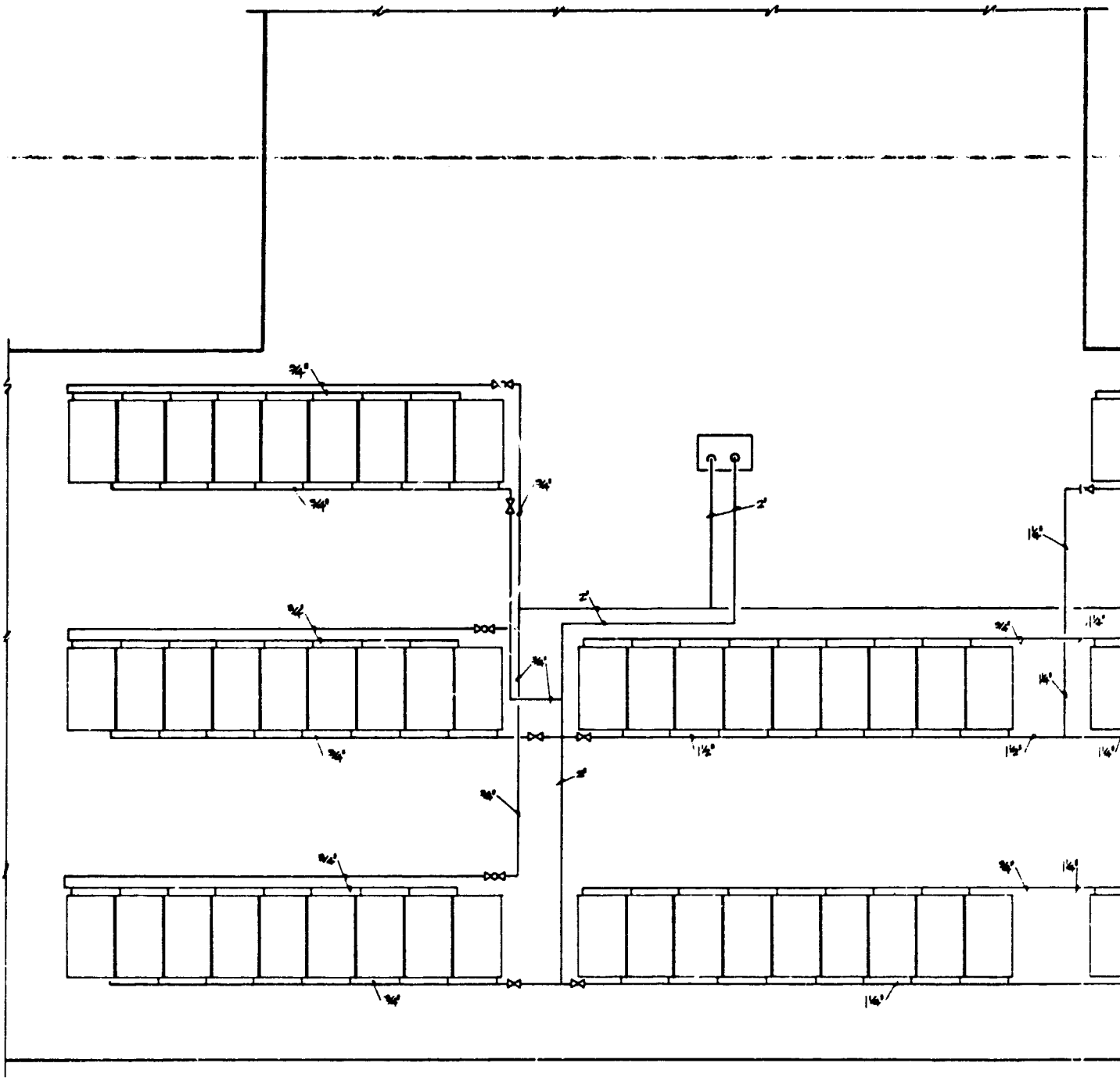


COLLECTOR PIPING & LAYOUT

SCALE: 1/4" = 1' - 0"

FOLDOUT FRAME

REVISION	DATE	DESCRIPTION
6		
5		
4		
3		
2		
1	1-24-79	COLLECTOR PIPING & LAYOUT AS-BUILT

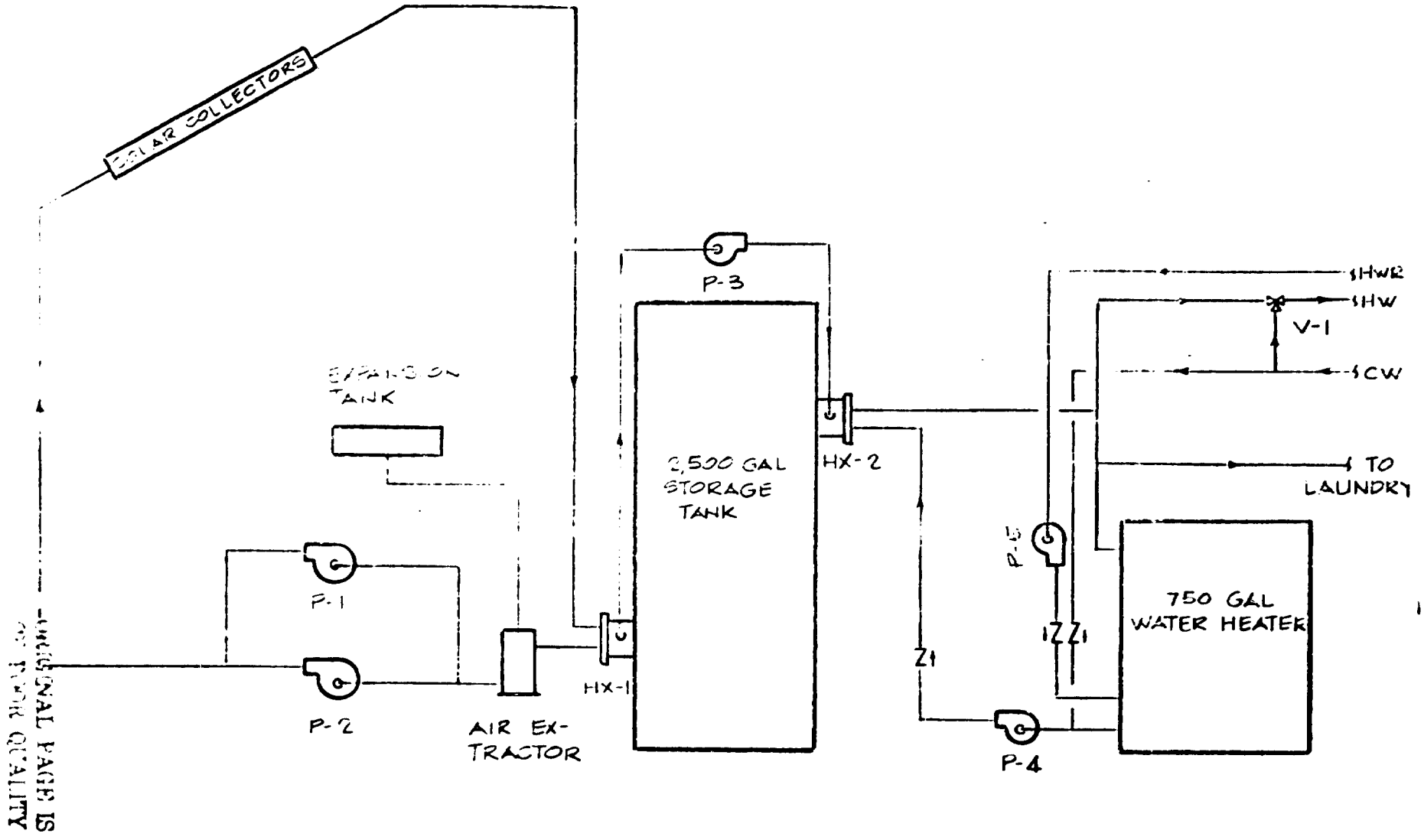
A-2

APPENDIX B

OPERATOR'S INSTRUCTIONS

AND

MAINTENANCE MANUAL



SOLAR SYSTEM SCHEMATIC

LA QUINTA MOTOR INN
TEXAS CITY, TEXAS

I

GENERAL DISCUSSION

This is a closed solar system utilizing two heat exchangers to transfer heat from the solar collectors to the domestic hot water system. Please refer to attached schematic drawing of the solar system.

P-1 and P-2 are solar loop pumps that circulate a solution of 30% ethylene glycol and 70% water between the solar collectors and the heat exchanger, HX-1. Only one solar loop pump is needed for the system operation, the other solar loop pump serves as 100% standby. The solar loop pumps are controlled by a temperature differential controller which starts the pump when the temperature at the solar collectors is 20°F higher than the temperature in the 2500 gallon storage tank. The temperature differential controller will deactivate the solar loop pump when the temperature at the solar collectors is not more than 3°F higher than the temperature in the 2500 gallon storage tank. An alternator alternates the operation of P-1 and P-2 for equal usage.

P-3 is a recirculating pump to improve the heat transfer between the heat exchangers and the stored water in the 2500 gallon storage tank. P-3 is interlocked with P-1 and P-2 so that if either P-1 or P-2 is activated, so will P-3. In addition, P-3 will activate when the ambient temperature is 32°F or lower.

When the temperature in the 2500 gallon storage tank reached a minimum of 15°F higher than the temperature of the water in the 750 gallon water heater, the temperature differential controller will activate pump P-4 to transfer the heat from the 2500 gallon storage tank to the building's hot water system. Pump P-4 will be deactivated when the temperature in the 2500 gallon storage tank is only 5°F higher than the temperature of the 750 gallon water heater.

P-5 is the usual hot water recirculating pump of the building's hot water system.

Mixing valve, V-1 is set to prevent the temperature of the hot water supplied to the building from exceeding 140°F.

II

MAINTENANCE REQUIREMENTS

1. Once a Week:

   a. Check fluid level in the solar system expansion tank. If low, add a 30-70 mixture of ethylene glycol and water to the system. CAUTION: NEVER ADD PLAIN WATER TO THE SYSTEM.

2. Once a Month:

   a. Wash glass surfaces of the solar collectors using a mild detergent solution and a soft brush. Thoroughly rinse with clean water.

   b. Check temperature differential controllers and alternator for proper operation.

   c. Check for fluid leaks from collectors and piping.

3. Once a Year:

   a. Check pump seals for leakage.

   b. Draw a sample of heat transfer fluid from the solar system for analysis and determination of any action needed to provide maximum corrosion inhibition.

APPENDIX C

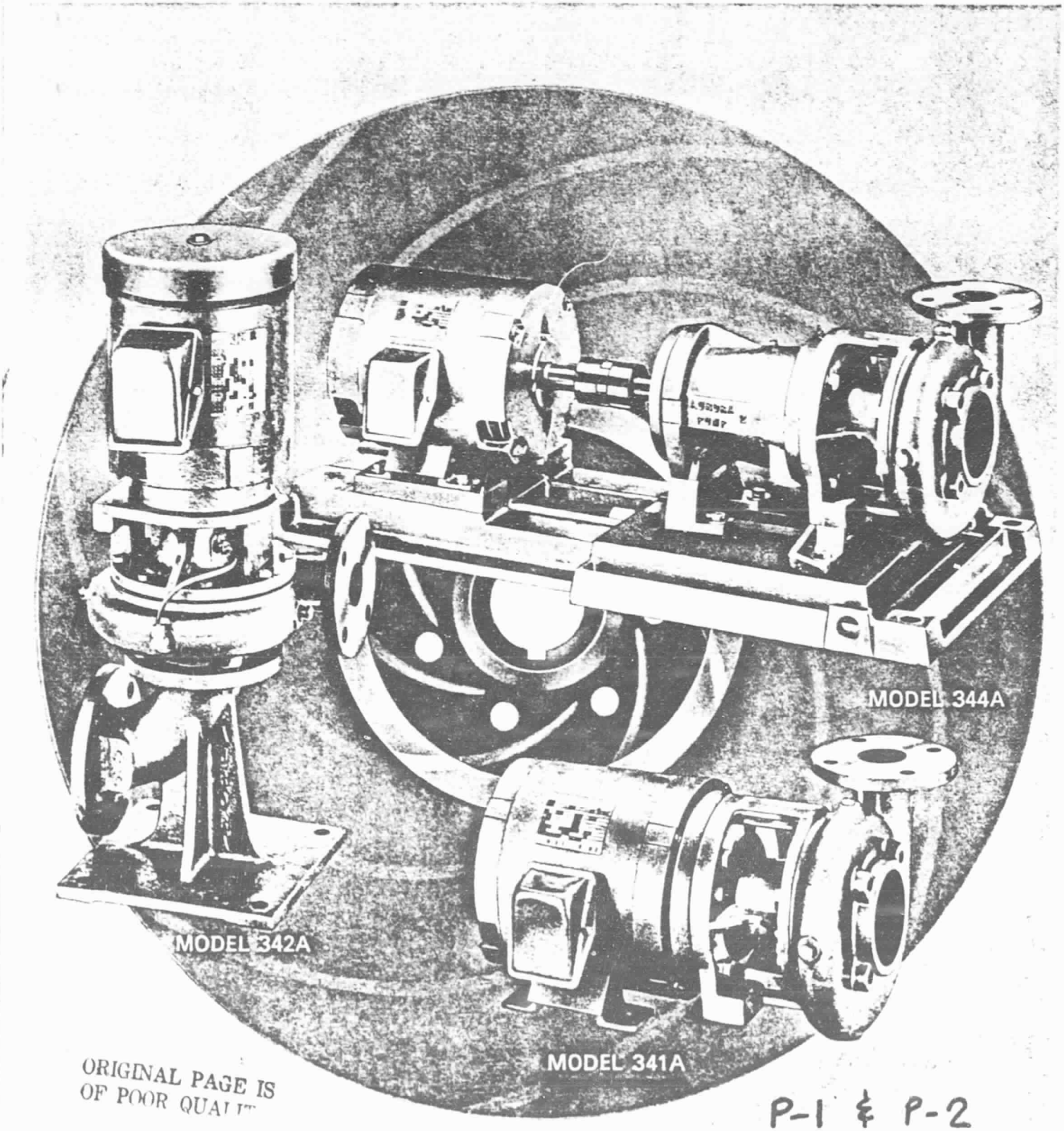
MANUFACTURER'S LITERATURE

AURORA® PUMPS

BULLETIN 340B

340 SERIES SINGLE STAGE END SUCTION PUMPS

CAPACITIES TO 1900 G.P.M.
HEADS TO 360 FEET
TEMPERATURES TO 225°F.



P-1 & P-2

ENGINEERING SPECIFICATIONS AND DIMENSIONS

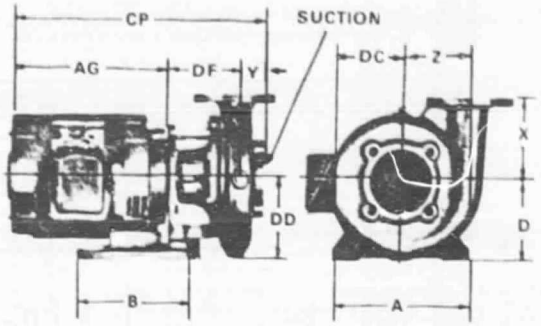
FLEXIBLE-CLOSE COUPLED PUMPS
The contractor shall furnish (and install as shown on the plans) Aurora Model (341A horizontal close coupled) (342A vertical close coupled) (344A horizontal flexible coupled) back pull out centrifugal pumps size . . . x . . . x . . . of (bronze fitted) (all iron) construction. Each pump shall have a capacity of . . . GPM at . . . ft. total head, with a temperature of . . . °F., . . . specific gravity and structureborne sound level not to exceed . . . ADB. Each pump is to be furnished with a mechanical seal with all metal parts to be 303 stainless steel with "Buna-N" elastomers, Ni-Resist seat, and carbon washer. The unit must be equipped with (bronze) (stainless steel) keylocked shaft sleeve that extends the length of the seal box. The pump shaft extension shall be "O" ring sealed from the pumped liquid. Pump shall have a case wearing ring (impeller wearing rings). Impellers to be vacuum cast, dynamically balanced, and keylocked to the shaft.

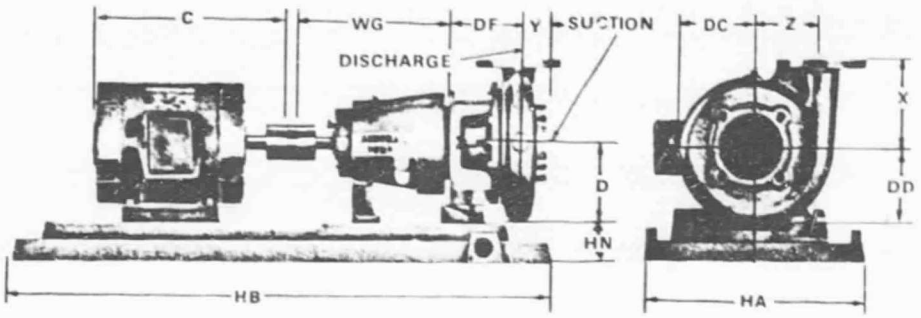
FLEXIBLE COUPLED PUMPS (344A)
Pump and motor are to be mounted on a common (fab. steel drip rim) (steel) baseplate. The shaft is to be steel, installed in a cast iron power frame. Pumps shall have a shaft design for .002" deflection at the seal face with the pump running under max. load condition. (Grease) (oil) lubricated ball bearings, having a 3 year min. life (AFBMA B_{10}) under the max. condition of load protected by separate oil seals and slingers, shall be used. The pump shall be flexible coupled to a standard horizontal NEMA . . . HP . . . phase . . . Hertz . . . volts . . . RPM (drip-proof) (totally enclosed) (explosion-proof) motor. Alignment shall be checked in accordance with the Standards of the Hydraulic Institute after installation and there shall be no strain transmitted to the pumps.

CLOSE COUPLED PUMPS (341A)
CLOSE COUPLED PUMPS (342A)
Each pump is to be close coupled to a standard HI-NEMA-JM . . . HP . . . phase . . . Hertz . . . volt . . . RPM (drip-proof) (totally enclosed) (explosion-proof) motor. Model 341A in motor frame sizes up to 184JM shall be supported by a separate support foot on the pump bracket.

NOTES
1. Dimensions and weights are approximate.
2. All dimensions are in inches and may vary ± ⅛".
3. Frame sizes "C", "B" & "A2" dimension is of motor; weight are for open drip-proof motors only.
4. Conduit box is shown in approximate position. Dimensions are not specified as they vary with each motor manufacturer.
5. Add pump, base and motor weight for unit weight.
6. Not for construction purposes unless certified.
7. Discharge position No. 2 and 3 is not available on Model 341A and 344A. Position No. 1 is furnished as standard unless otherwise specified. See page 4.
8. Aurora Pump reserves the right to make revisions to its products and their specifications, and to this bulletin or related information, without notice.
9. When "HB" dimensions are indicated, always use the larger.
10. Note: Power frame selection can be made from the range charts.

*Model 341A & 342A have "JM" motor frames.
Model 344A have "T" frame motors.





PUMPS WITH THREADED CONNECTIONS

PUMP SIZE DISCH.	SUC-TION	CASE BORE	PUMP WEIGHT IN LBS.	X	Y	Z	DC	DD	DF FRAME 1 143 JM-213 JM	DF FRAME 2 or 3 254 JM-256 JM	VD	VE	VY
1-1/4	1-1/2	7	52	5-1/4	2-7/16	4-3/16	4-15/16	5-3/16	4-3/4	—	9-3/8	3-3/4	4
1-1/4	1-1/2	9	71	6-5/8	2-9/16	5-3/8	6-3/16	6-3/8	4-11/16	—	9-3/8	3-3/4	4
1-1/2	2	7	56	5-3/8	2-1/2	4-5/16	5-1/8	5-3/8	4-13/16	—	10-5/16	4-1/8	4-1/2
1-1/2	2	9	76	6-3/4	2-5/8	5-1/2	6-5/16	6-9/16	4-3/4	5-3/4	10-5/16	4-1/8	4-1/2
1-1/2	2	12	112	7-3/4	2-3/4	7-1/16	8	8-1/4	4-7/8	5-7/8	10-7/16	4-1/8	4-1/2
PUMPS WITH AM. STD. 125 LBS. FLANGED CONNECTIONS													
2	2-1/2	7	68	5-5/8	1-7/8	4-9/16	5-3/8	5-13/16	4-15/16	5-15/16	11-7/16	4-1/2	5
2	2-1/2	9	94	7	1-7/8	5-11/16	6-1/2	6-7/8	4-7/8	5-7/8	11-7/16	4-1/2	5
2	2-1/2	12	142	8	1-7/8	7-3/16	8-3/16	8-1/2	5	6	11-7/16	4-1/2	5
2-1/2	3	7	73	5-7/8	2	4-13/16	5-13/16	6-1/4	5-1/16	6-1/16	12-9/16	5	5-1/2
2-1/2	3	9	101	7-1/4	2	5-15/16	6-3/4	7-1/4	5	6	12-9/16	5	5-1/2
2-1/2	3	12	142	8-1/4	2	7-3/8	8-3/8	8-3/4	5-1/8	6-1/8	12-9/16	5	5-1/2
3	4	9	104	7-1/2	2-1/8	6-1/8	6-7/8	7-7/16	5-1/8	6-1/8	14-11/16	6	6-1/2
3	4	12	158	8-1/2	2-1/8	7-9/16	8-7/16	8-15/16	5-1/4	6-1/4	14-11/16	6	6-1/2
4	4	7	103	6-1/2	2-1/2	5-1/2	6-7/16	7-5/16	5-7/16	6-7/16	14-15/16	6	6-1/2
4	5	9A	133	7-1/4	3-1/8	5-3/4	6-11/16	7-3/8	5-1/4	6-1/4	17-3/16	6-1/2	7-1/2
4	5	9B	133	7-3/4	2-5/8	6-5/8	8-1/16	8-11/16	5-3/8	6-3/8	16-11/16	6-1/2	7-1/2
4	5	12	176	8-3/4	2-5/8	7-15/16	8-7/8	9-9/16	—	6-1/2	16-11/16	6-1/2	7-1/2
*5	6	12	195	9	2-7/8	8-5/16	9-1/4	10-1/8	—	6-3/4	—	—	—
6	6	9	164	8-1/4	2-3/4	7	8	9	5-1/2	6-1/2	17-13/16	7	8
*6	6	12	221	9-1/4	3-1/8	8-11/16	9-11/16	10-13/16	—	7	—	—	—

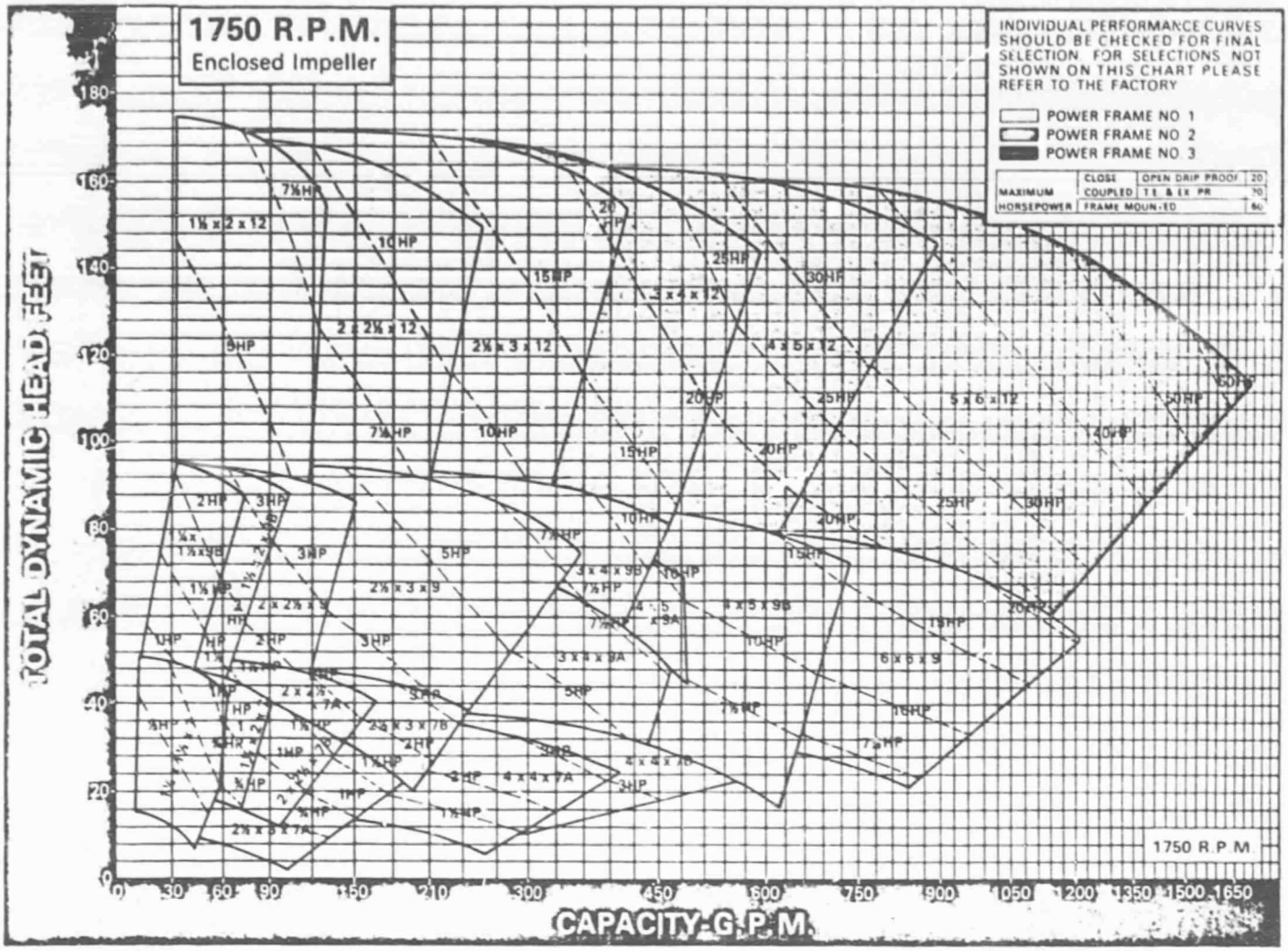
*Not available in Models 341A and 342A.

PUMP MODEL	BASE NUMBER	WEIGHT IN POUNDS	HA	HB	HN
344A	1	100	14-1/2	42-3/4	3-1/2
	2	110	17	43	3-1/2
	3	175	19	51	4-1/2

POWER FRAME		1	2	3
WEIGHT IN POUNDS		36	82	87
D	CASE BORE 7 & 12	5-1/4 6-1/4	6-1/4 7	— 7
WG		10-5/16	13-13/16	13-13/16

PUMP MODEL	MOTOR FRAME	HORSEPOWER 3500 RPM	HORSEPOWER 1750 RPM	MOTOR WEIGHT IN LBS.	D	PUMP MODEL 341A & 342A A	B	AG	C	BASE NUMBER		
344A	56	—	1/3-1/2-3/4	50	5-1/4	—	—	—	12	1	—	—
	143T	1-1/2	1	30	5-1/4	9-3/4	8-5/8	10	11	1	—	—
	145T	2-3	1-1/2-2	35	5-1/4	9-3/4	8-5/8	11	12	1	2	—
341A	182T	5	3	45	5-1/4	9-3/4	8-5/8	11	13	1	2	—
342A†	184T	7-1/2	5	50	5-1/4	9-3/4	8-5/8	12	14	1	2	—
&	213T	10	7-1/2	120	5-1/4	10-1/2	7-1/2	14	16	1	2	—
344A	215T	15	10	144	5-1/4	10-1/2	9	15	18	1	2	—
	254T	20	15	217	6-1/4	12-1/2	10-3/4	17	21	1	3	3
	256T	25	20	246	6-1/4	12-1/2	12-1/2	19	23	—	3	3
	284T	—	25	320	7	—	—	—	24	—	3	3
	284TS	30	—	320	7	—	—	—	22	—	3	2
	286T	—	30	351	7	—	—	—	25	—	3	3
	286TS	40	—	351	7	—	—	—	24	—	3	3
344A	324T	—	40	442	8	—	—	—	26	—	3	3
	324TS	50	—	442	8	—	—	—	25	—	3	3
	326TS	60	50	522	8	—	—	—	26	—	3	3
	364TS	75	60	625	9	—	—	—	27	—	3	3

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542
SALES OFFICES IN ALL MAJOR CITIES AND COUNTRIES
Refer to "Pumps" in the yellow pages of your phone directory
MANUFACTURING FACILITIES ARE LOCATED IN THE FOLLOWING CITIES: NORTH AURORA, ILLINOIS • CITY OF INDUSTRY (GREATER LOS ANGELES), CALIFORNIA
Export Dept. No. Aurora, Illinois. Cable Address "NYABINT"



MATERIAL OF CONSTRUCTION

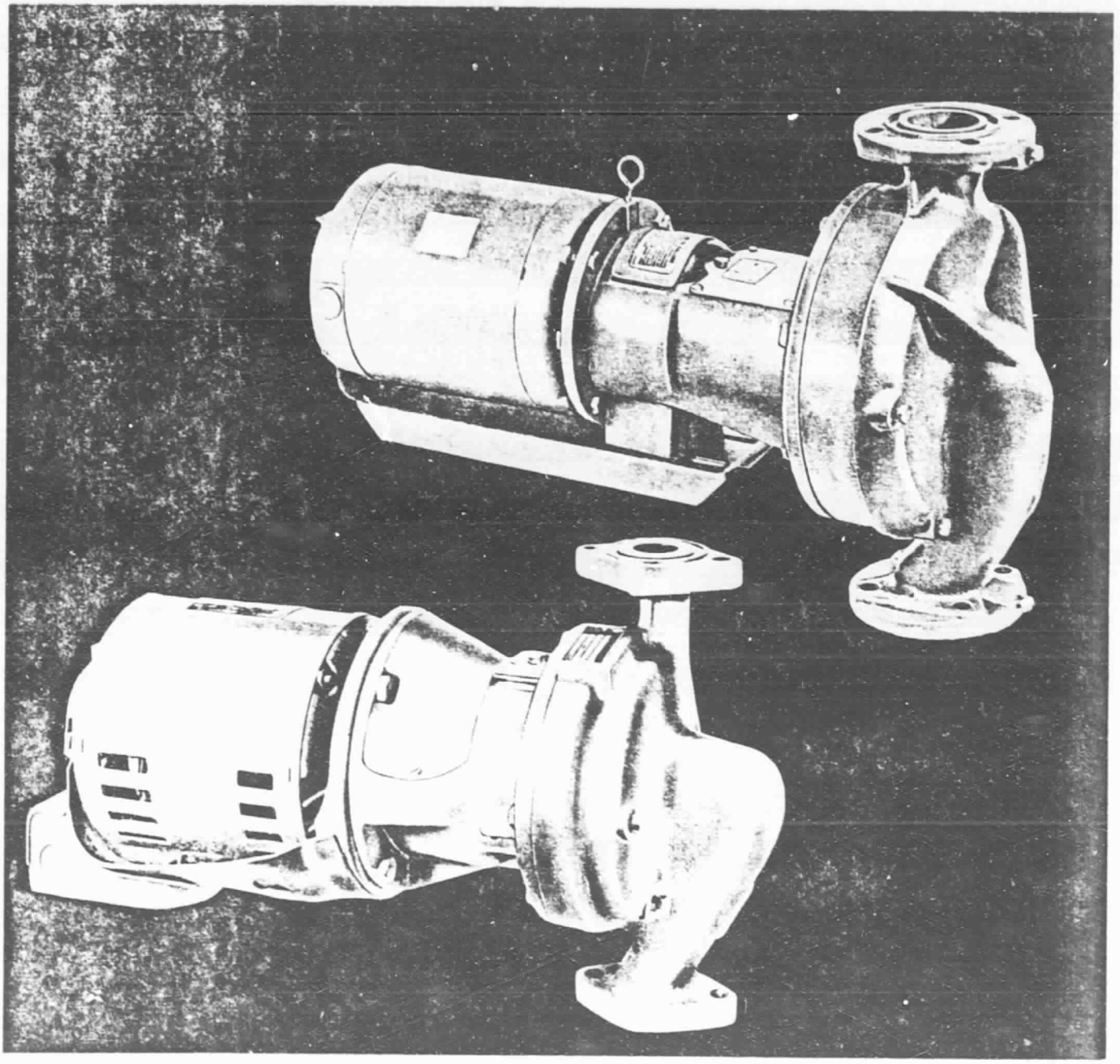
PUMP PART	BRONZE FITTED	ALL IRON
CASING	CAST IRON ASTM A48	CAST IRON ASTM A48
CASE WEARING RING	BRONZE ASTM B62	CAST IRON ASTM A48
IMPELLER	BRONZE ASTM B584	CAST IRON ASTM A48
MOTOR BRACKET	CAST IRON ASTM A48	CAST IRON ASTM A48
SHAFT	STEEL AISI C1045	STEEL AISI C1045
SLEEVE	BRONZE ASTM B62	STAINLESS STEEL AISI 316
POWER FRAME (344)	CAST IRON ASTM A48	CAST IRON ASTM A48
MECHANICAL SEAL	303 STAINLESS STEEL METAL PARTS, "Buna-N" ELASTOMER PARTS, NI-RESIST SEAT AND CARBON WASHER	

LIMITATIONS

MAXIMUM LIMITATIONS BASED ON STANDARD MATERIALS AND PUMPING CLEAR WATER

SPEED—RPM			3600
HORSEPOWER *At 1750 R.P.M., 20 H.P. †At 1750 R.P.M., 60 H.P.	CLOSE COUPLED	O.D.P.	25*
		T.E. & EX. PR.	20
	FRAME MOUNTED		75†
TEMPERATURE-°F	CLOSE COUPLED		225
	FRAME MOUNTED		225
HYDROSTATIC TEST PRESS.- PSI	7" & 9" BORE PUMPS UP TO 1½" DISCH.		265
	9" BORE PUMPS 2" DISCH. & LARGER		265
	ALL 12" BORE PUMPS		265
CASE WORKING PRESSURE PSI (ALL OR ANY PART CAN BE SUCTION PRESSURE)	7" & 9" BORE PUMPS UP TO 1½" DISCH.		175
	9" BORE PUMPS 2" DISCH. & LARGER		175
	ALL 12" BORE PUMPS		175

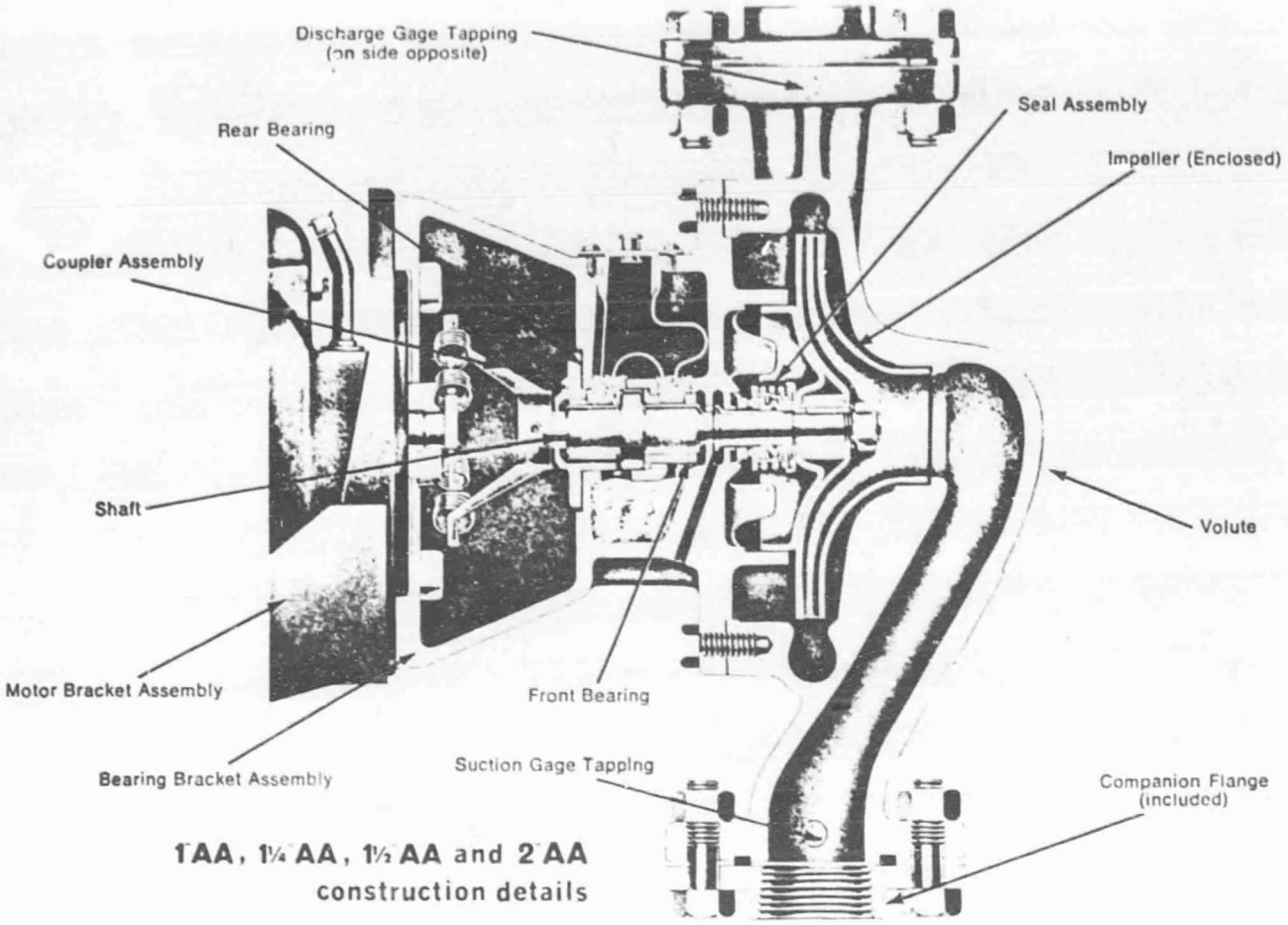
DETAILS ARE AVAILABLE FROM FACTORY.



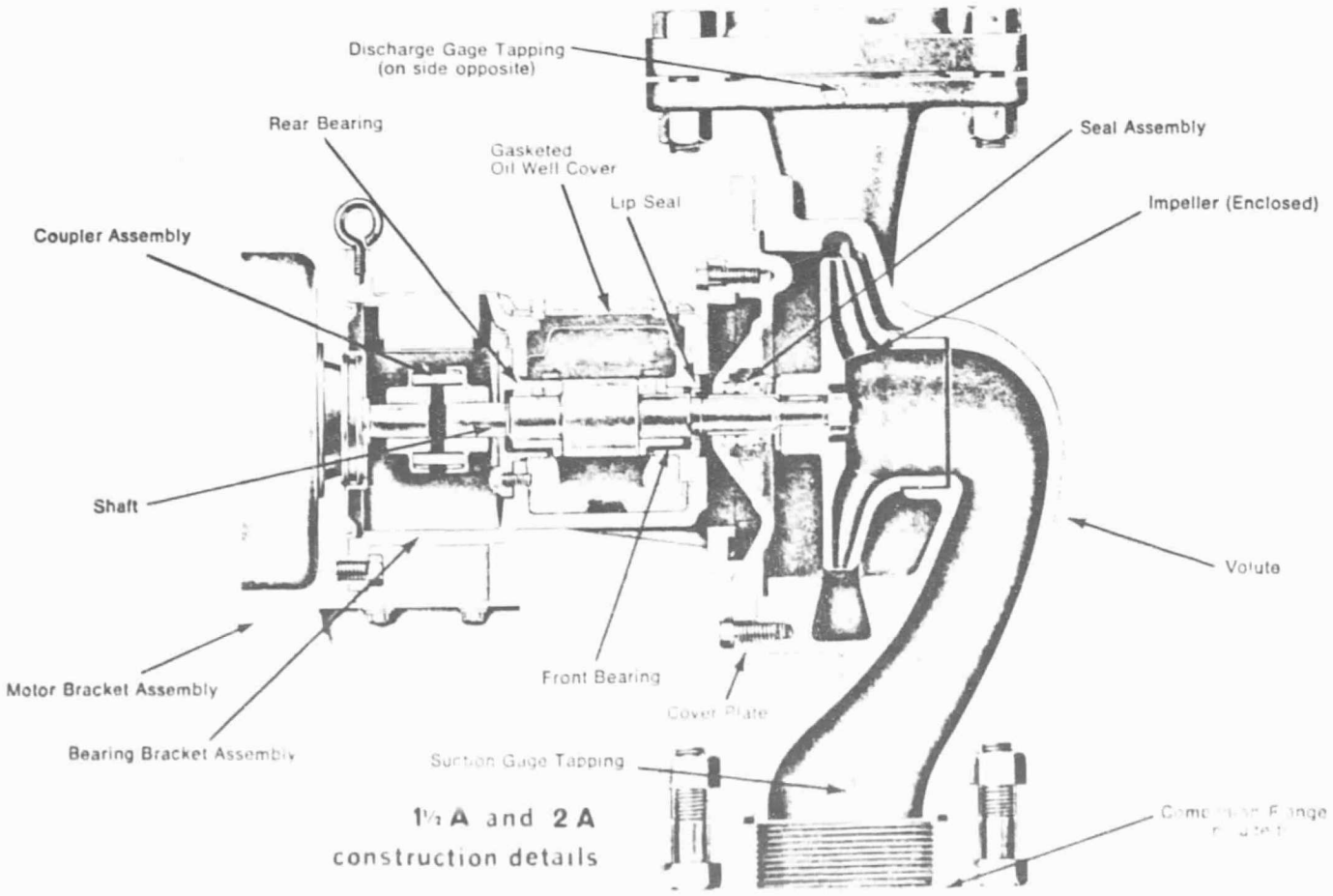
SERIES 60
the extra quiet
in-line pump for general services

P- 4

BELL & GOSSETT ITT
FLUID HANDLING DIVISION



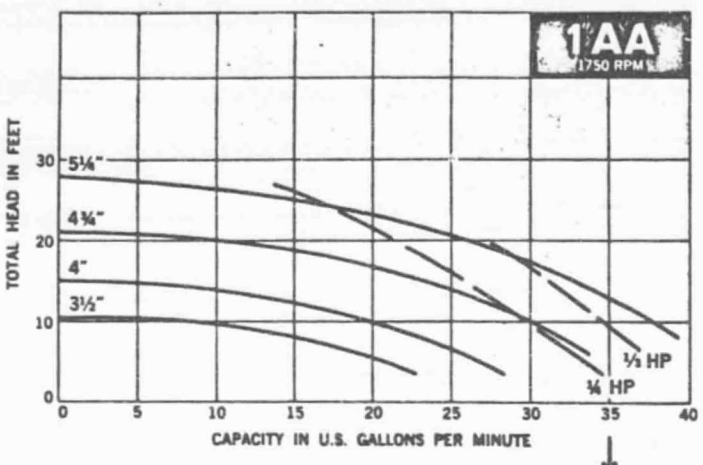
1AA, 1¼AA, 1½AA and 2AA construction details

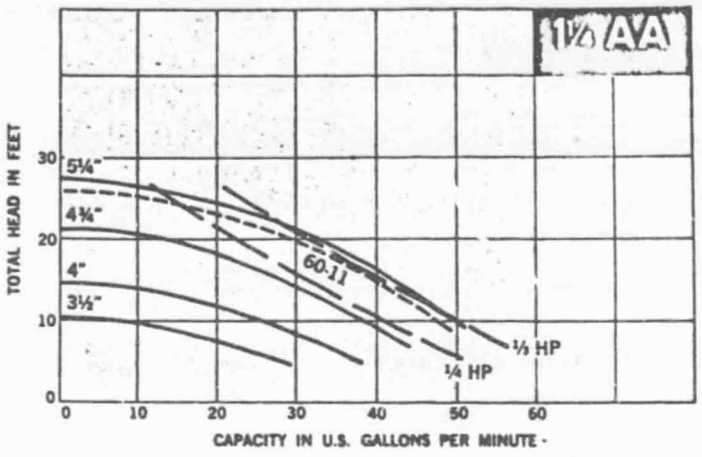


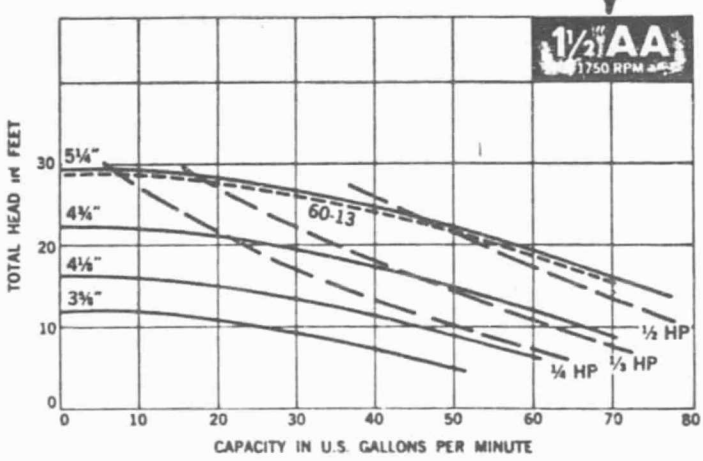
1½A and 2A construction details

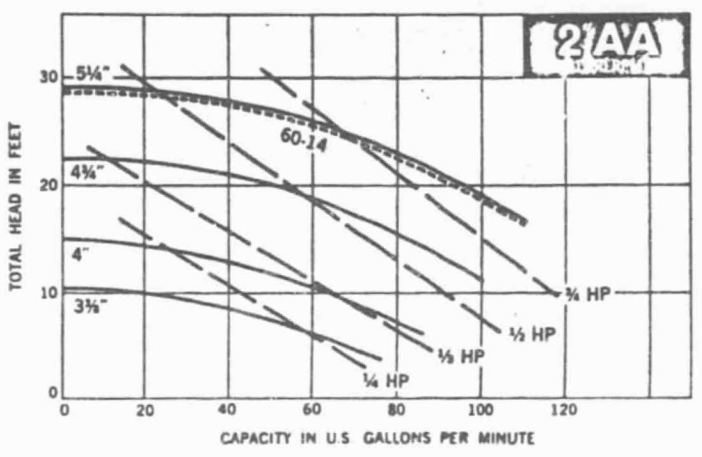
Series 60 Pumps can be furnished in bronze-fitted, all iron, or all bronze construction to suit your application

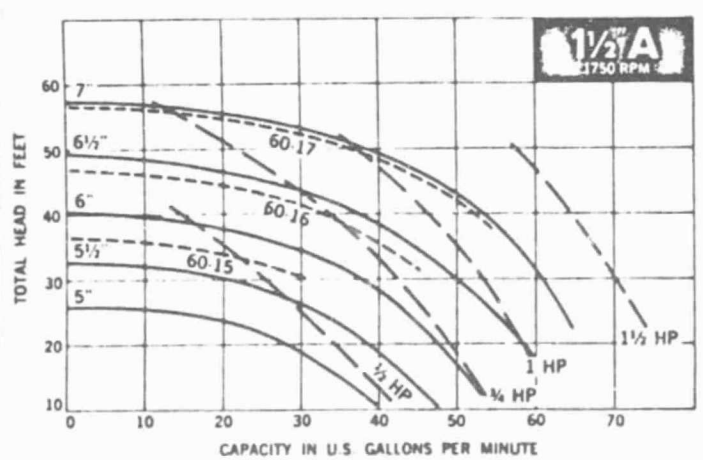
DOTTED-IN CURVES REPRESENT STOCK PUMP SELECTIONS

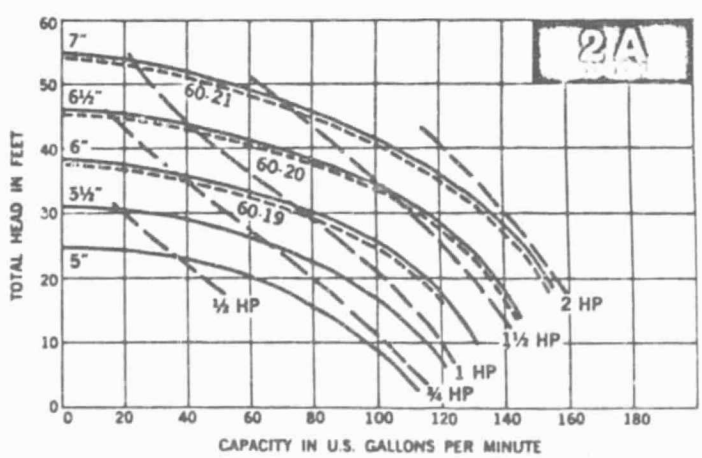












Curves based upon shop test using clear cold water
at a temperature of not over 85° F.
Horsepower curves do not include motor service factor.

Dimensions

FIG. 1 AA SIZES

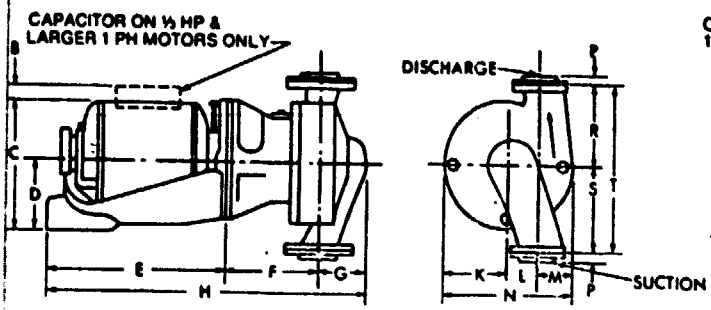
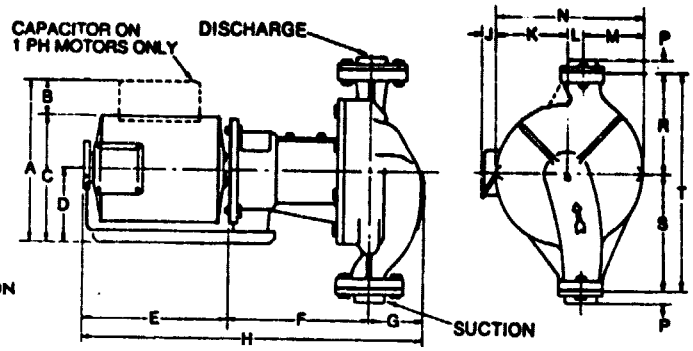


FIG. 2 A SIZES



STANDARD VOLTAGES

¼ HP, 1 PH, 115 Volts. ⅓ to 1½ HP, 1 PH, 115/230 Volts. ¼ to ¾ HP, 3 PH, 200-230/460 Volts. 1 to 2 HP, 208 or 230/460 Volts.
All single phase motors have built-in overload protection.

Companion flanges furnished for suction and discharge

STOCK PUMP MODEL	PUMP SIZE	DRIPPROOF MOTOR HP	SUCTION & DISCHARGE SIZE (NPT)	DIMENSIONS IN INCHES				
				A	B	C	D	E
—	1AA	¼	1	15 13/16	11	4⅜	6⅛	3 7/16
—	1AA	⅓	1	16 13/16	11	4⅜	6⅛	3 7/16
60-11	1¼AA	¼	1¼	15 13/16	11	5	7½	3 7/16
—	1¼AA	⅓	1¼	16 13/16	11	5	7½	3 7/16
—	1¼AA	½	1¼	17 5/16	11	5	7½	3 7/16
—	1½AA	¼	1½	16	11½	5⅛	7⅞	3⅝
—	1½AA	⅓	1½	17	11½	5⅛	7⅞	3⅝
60-13	1½AA	½	1½	17½	11½	5⅛	7⅞	3⅝
—	1½AA	¾	1½	18	11½	5⅛	7⅞	3⅝
—	2AA	¼	2	16⅛	11½	5⅛	8	3¾
—	2AA	⅓	2	17⅛	11½	5⅛	8	3¾
—	2AA	½	2	17⅝	11½	5⅛	8	3¾
60-14	2AA	¾	2	18⅛	11½	5⅛	8	3¾
60-15	1½A	½	1½	20¼	13½	5⅝	9½	3¼
60-16	1½A	¾	1½	21¾	13½	5⅝	9½	3¼
60-17	1½A	1	1½	19⅞	13½	5⅝	9½	3¼
—	1½A	1½	1½	20⅝	13½	5⅝	9½	3¼
—	2A	½	2	21¼	14	5¾	9⅞	3½
—	2A	¾	2	21¾	14	5¾	9⅞	3½
60-19	2A	1	2	19¾	14	5¾	9⅞	3½
60-20	2A	1½	2	20⅝	14	5¾	9⅞	3½
60-21**	2A	2**	2	21⅜	14	5¾	9⅞	3½

**Not available in single phase.

Dimensions are approxin ate and not to be used for construction purposes.

Construction Materials

FOR PARTS IN CONTACT WITH FLUID PUMPED

DESCRIPTION	BRONZE FITTED PUMP	ALL IRON PUMP	ALL BRONZE PUMP
Volute	Cast Iron	Cast Iron	Bronze
Bearing Bracket	Cast Iron	Cast Iron	Iron with Brass Face Plate
Impeller	Brass	Steel (AA)/Cast Iron (A)	Brass
Impeller Key	Steel	Steel	Steel
Impeller Lock Washer	Steel	Steel	Brass
Impeller Lock Nut	Brass (AA) Steel (A)	Plated Steel	Brass
Pump Shaft	Steel	Steel	Steel
Shaft Sleeve	Copper	Stainless Steel	Copper
Seal Assembly	Carbon Seal Ring, Ceramic Seat, Synthetic Rubber Bellows and Stainless Steel Spring		

APPENDIX D

VERIFICATION

La Quinta

MOTOR INNS, INC

VERIFICATIONS

1. Final Field Inspection:

   A team consisting of Jimmy Carter, Ronald Wang (Owner's Representatives), Steve Huck (Inspecting Engineer), and Phil Nutter (Installing Contractor) met for final inspection on November 5, 1979.

   The installation was found to be complete and operating as called in the plans. The control system was checked out and confirmed to be performing as designed.

2. Data Obtained During Final Field Inspection:

   Please see attached sheets.

3. Acceptance:

   The installation is considered complete and accepted.

Ronald K. Wang
Mechanical/Electrical Engineer
Development Division

RW:cs

AEC

TEL. (512) 349-3628

November 20, 1979

Mr. Ronald Wong
LaQuinta Motor Inns, Inc.
Century Building
P.O. Box 32783
San Antonio, TX 78216

Dear Mr. Wong:

This letter is sent to you along with the enclosed plan and pictures to summarize our firms site visit and system analysis of the Texas City solar system conducted on November 5.

System temperature and pressure observations were recorded on the hour from 10:00 a.m. to 1:00 p.m. inclusive. The results of those observations, at various system locations, are included on the plan.

Also included is an energy analysis performed on the system for noon conditions. As the results of the calculation indicate, based on the stated assumptions, a reasonably good comparison results between the observed conditions and theoretical solar inputs.

The performed calculation are outlined in detail on the enclosed sheet. More accurate solar energy insolation and pump performance would of course allow for a more accurate determination of the calculated temperature rise. With the available information though a sufficiently good comparison does result between the calculated and observed collector performance.

For this reason, I definitely feel the solar collector array is performing as it should.

Yours very truly,

Steven E. Huck

Enclosure

cc: Lynne Judge
Marvin Ruben

3355 CHERRY RIDGE — SUITE 211 — SAN ANTONIO, TEXAS 78230

CALCULATION OF THEORETICAL SOLAR ARRAY PERFORMANCE

1. Solar Insolation available based on assumption that Texas City insolation on November 5 does not deviate significantly for insolation values for 32° North latitude and a 32° collector slope. From ITT's "Solar Systems Design Manual" insolation values for October 21 and November 21 are 320 BTU/sq. ft.-hr. respectively. Assume November 5 is average of two or 312 BTU/sq. ft.-hr. Also assume a 10% reduction in solar energy available due to Texas City haze, therefore estimated incident solar energy = 280 BTU/sq. ft.-hr.

2. Average collector plate temperature at noon was
   $((171-166)/2) + 166 = 169^{\circ}$ F

3. Recorded ambient temperature was 75° F

4. Determine collector efficiency from Raypack literature based on 1,2 & 3 above or (169 - 75)/280 = 0.34 for a collector efficiency of 40%.

5. Total collected energy per collector
   = 280 BTU/sq. ft. - hr. x 0.4 x 17.3 sq. ft. = 1940 BTU/hr.

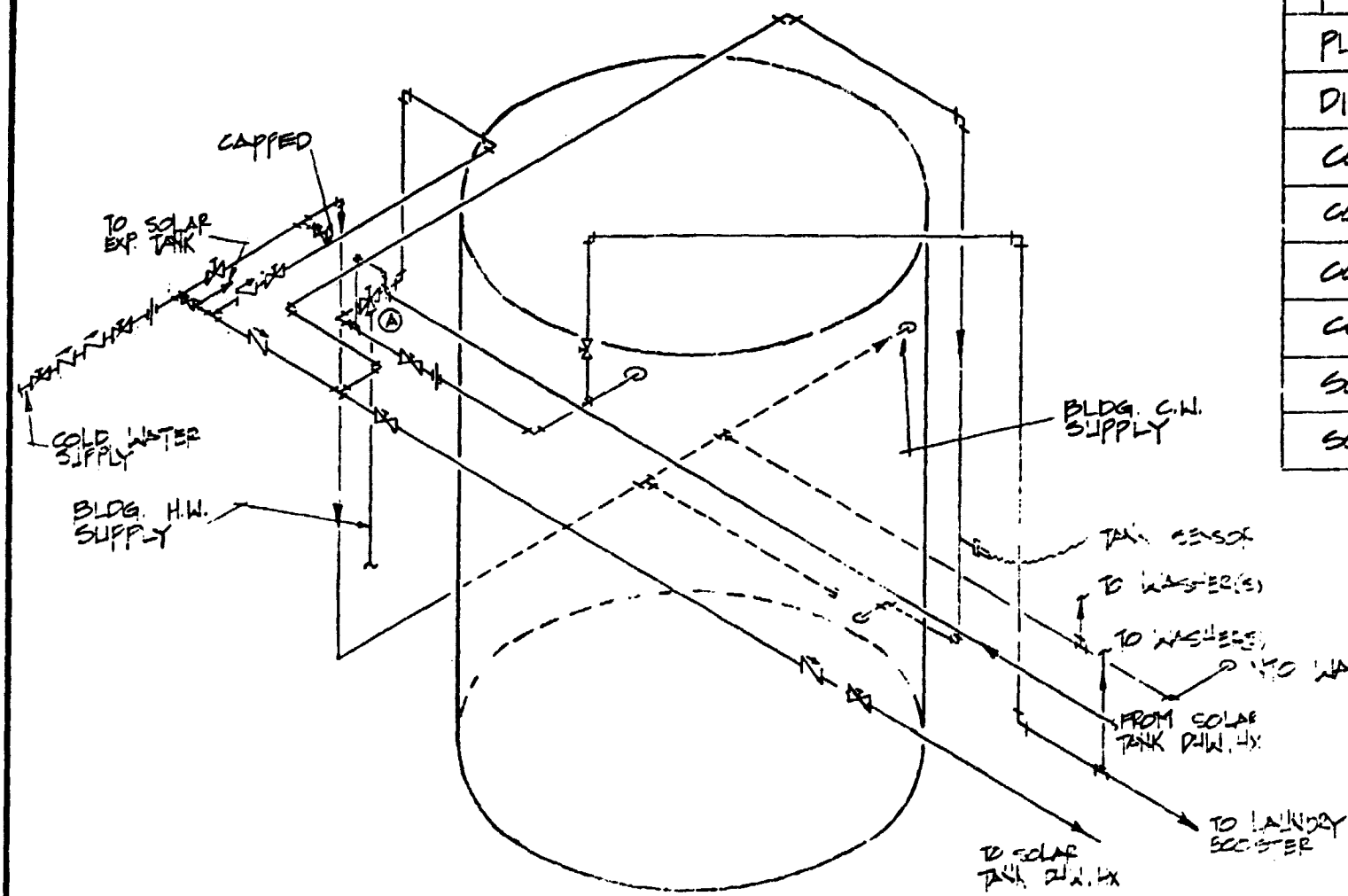
6. Aurora pump curve based on noon pump conditions indicates flow rate at approximately 60 gpm.

   60 gpm/99 collectors = 0.61 gpm/collector
   = 37 gph/collector
   = 305 lb/hr/collector

7. $\frac{1940 \text{ BTU HR LB } ^{\circ}\text{F}}{305 \text{ LB HR 1 BTU}} = \underline{6.4^{\circ} \text{ F}}$

8. Temperature rise recorded at noon was 5° F.

9. Therefore a sufficiently accurate comparison indicates collectors to be performing as required.



A - TEMPERING VALVE

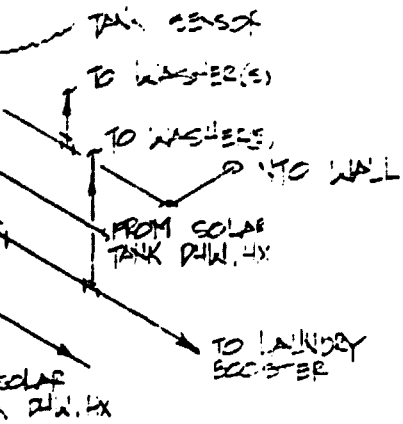
HOT WATER HEATER AT MECHANICAL RM. - ISOMETRIC

NO SCALE

FOLDOUT FRAME

TIME	10 AM	11 AM	NOON	1 PM
PUMP SUCTION TEMP. (°F)	144	—	169	171
PUMP SUCTION PRESSURE (PSI)	25	34	36	36
PUMP DISCHARGE PRESSURE (PSI)	69	65	64	65
DIFFERENTIAL PUMP PRESSURE (FT. HD)	--	67	65	67
COLLECTOR INLET TEMPERATURE (°F)	146	158	166	169
COLLECTOR OUTLET TEMPERATURE (°F)	150	162	171	173
COLLECTOR INLET PRESSURE (PSI)	44	42	50	50
COLLECTOR OUTLET PRESSURE (PSI)	48	45	48	48
SOLAR HX INLET TEMPERATURE (°F)	148	—	171	175
SOLAR HX OUTLET TEMPERATURE (°F)	146	—	168	171

BLDG. C.W. SUPPLY



WEATHER: CLEAR, WINDY FROM S.E., TEMP. - 75°F @ 1 PM

ORIGINAL PAGE IS OF POOR QUALITY

FOLDOUT FRAME

METRIC

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

A QUALITY MOTOR INNS
TEXAS CITY, TEXAS

ANDERSON ENGINEERING COMPANY

DRAWN BY S. G. I.	SCALE NONE	MATERIAL
CHK'D S. E. H.	DATE	DRAWING NO
TRACED	APP'D	1 OF 1

La Quinta
MOTOR INNS, INC.

October 29, 1980

National Aeronautics & Space Administration
Commercial Demonstration Office
Solar Energy Applications Projects
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Attention: Mr. Douglas W. Westrope, Jr.
Project Manager

Subject: La Quinta Motor Inns, Inc.
Texas City, Texas #533
Solar Installation

Dear Doug:

Attached is the final report on the above subject installation. Original tracings of drawings are included for your use.

Please call me if you have any questions.

Sincerely,

Ronald Wang
Mechanical/Electrical Engineer
Development Division

RW:cs

Attachments

cc: Martin Carson/file

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Development Division
Century Building • P.O. Box 32783 • San Antonio, Texas 78216 • 512-349-1221